Agent-based analysis of dynamic access ranges to the distribution network

Innovative Smart Grid Technologies 2016

Sébastien Mathieu, Damien Ernst, Bertrand Cornélusse

Université de Liège

Outline

Congestion in distribution networks

- Distributed generation, such as wind farms, causes congestions in distribution networks.
- The solution is to upgrade the network or to use the flexibility within the network:
  1. curtail the production,
  2. shift the consumption.
- The Distribution System Operator (DSO) does not own the flexible assets.
- Using flexibility impacts financially the flexible assets owners.

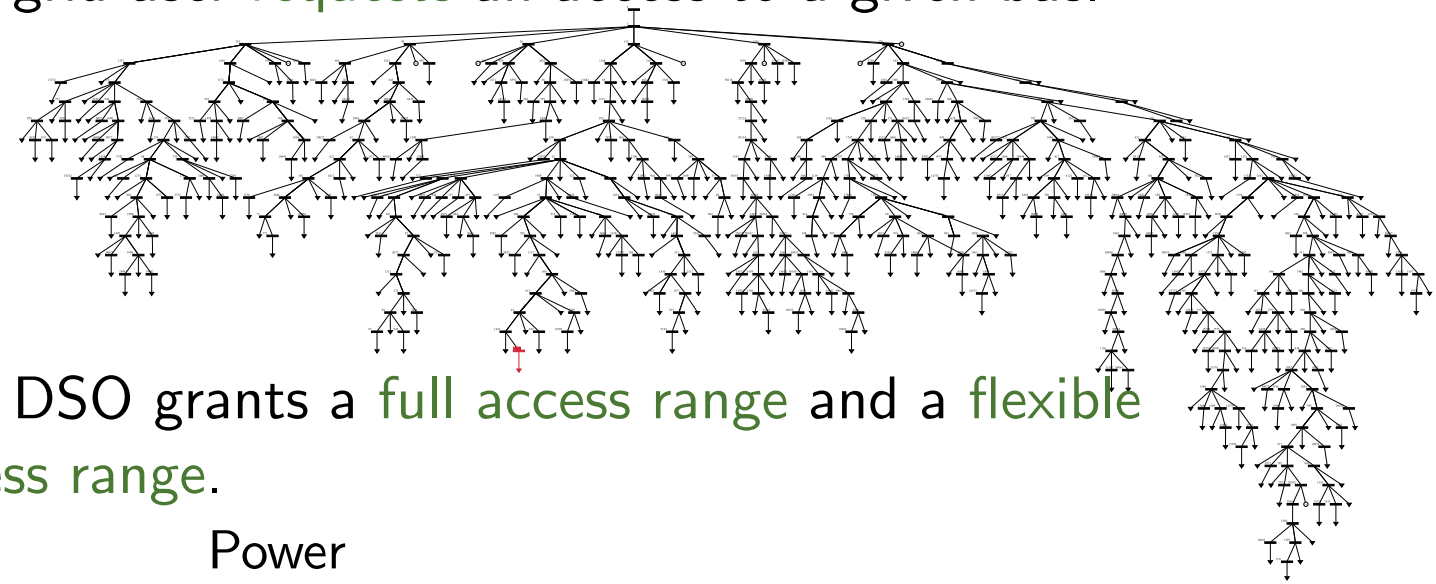
A framework, called an interaction model, is needed to define how flexibility should be exchanged in distribution networks.

Outline

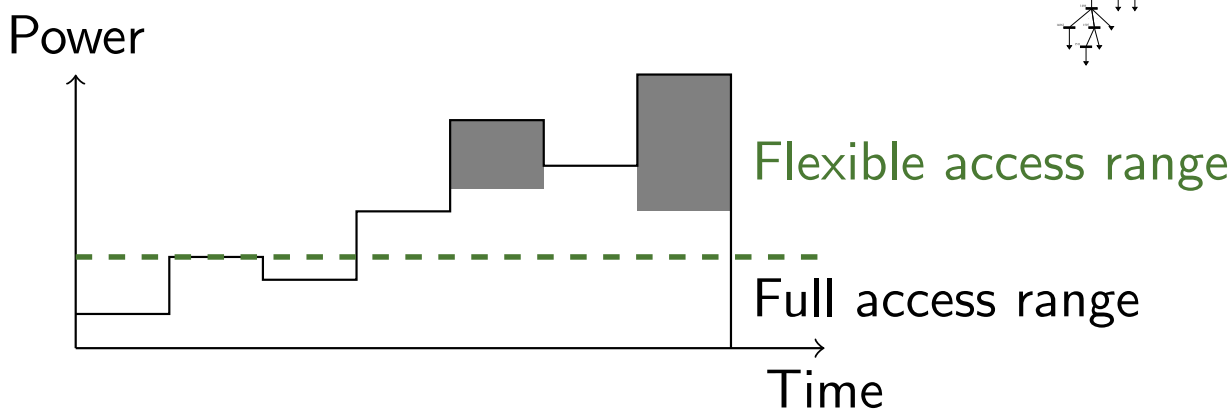
Access agreement

The interaction models are based on access contracts.

- The grid user requests an access to a given bus.



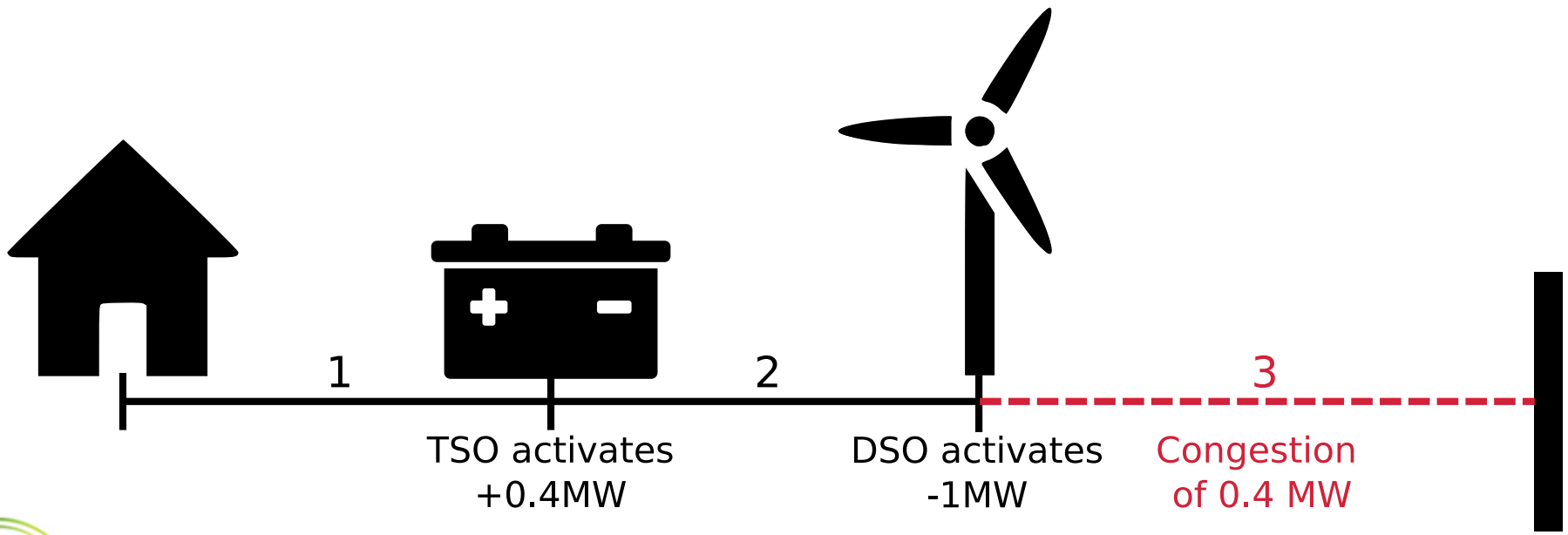
- The DSO grants a full access range and a flexible access range.



The filled areas represents the restrictions of the DSO.

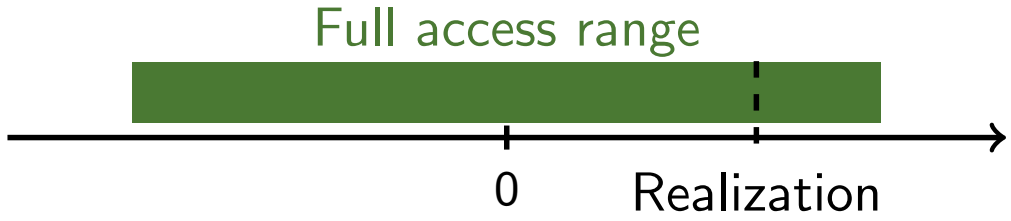
Coordination problem

- Assume that the flow exceeds the capacity of line 3 by 1MW.
- To solve this issue, the DSO curtails a wind mill by 1MW.
- Simultaneously, the TSO asks a storage unit to inject 0.4MW.
- These activations lead to a remaining congestion of 0.4MW.



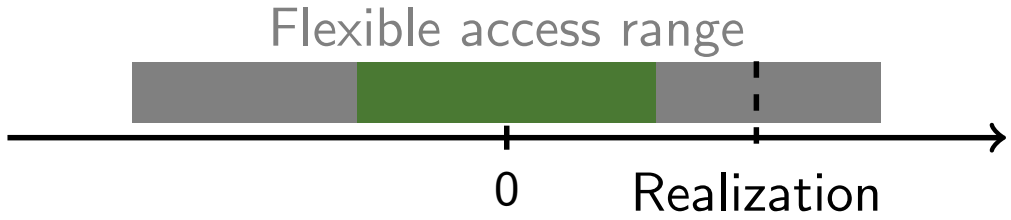
Coordination problem: two causes

1. The storage unit is in its safe range:

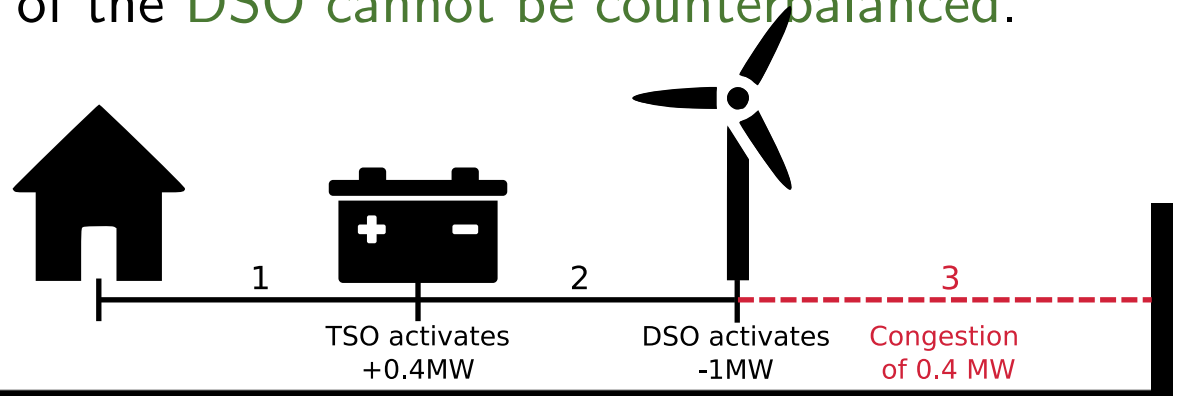


The DSO should anticipate the deviation of the storage unit.

2. The storage unit is out of its safe range:



The production of the storage unit should be limited so that the actions of the DSO cannot be counterbalanced.



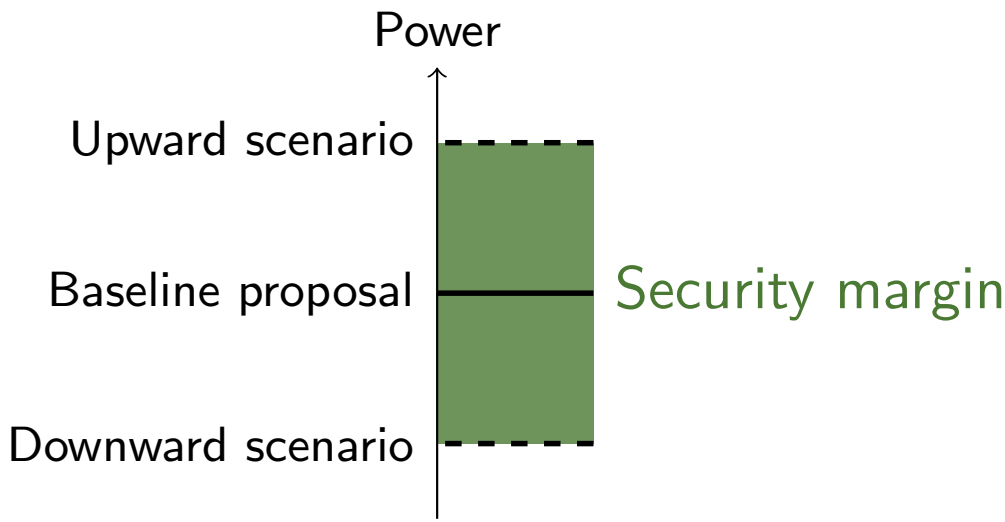
Outline

Dynamic access ranges: definition

The dynamic (full) access ranges change each quarter based on the distribution network limitations computed by the DSO.

The procedure to obtain the dynamic ranges is:

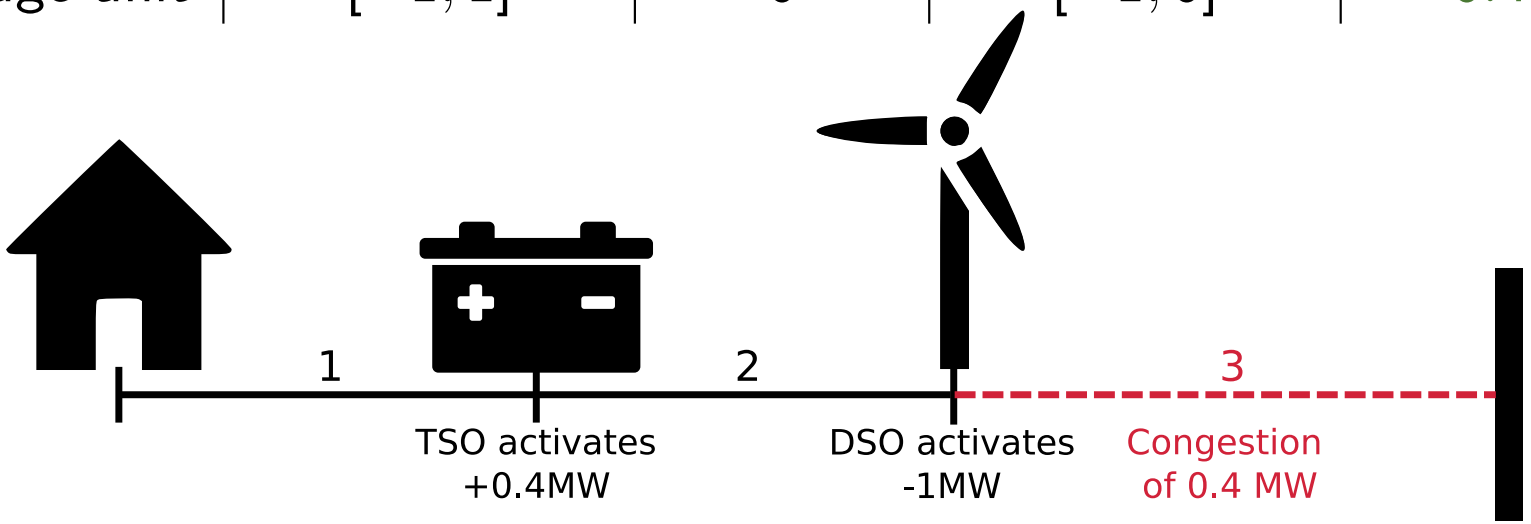
1. Grid users provide baseline proposals.
2. The DSO computes the dynamic ranges and communicates them to grid users.



3. Grid users submit new baselines within the dynamic range.

Dynamic ranges: back to our coordination problem

	Safe access range	**Baseline proposal**	**Dynamic access range**	**Previous Solution**
Wind mill	$[0, 5]$	7	$[0, 6]$	6
Storage unit	$[-1, 1]$	0	$[-1, 0]$	0.4

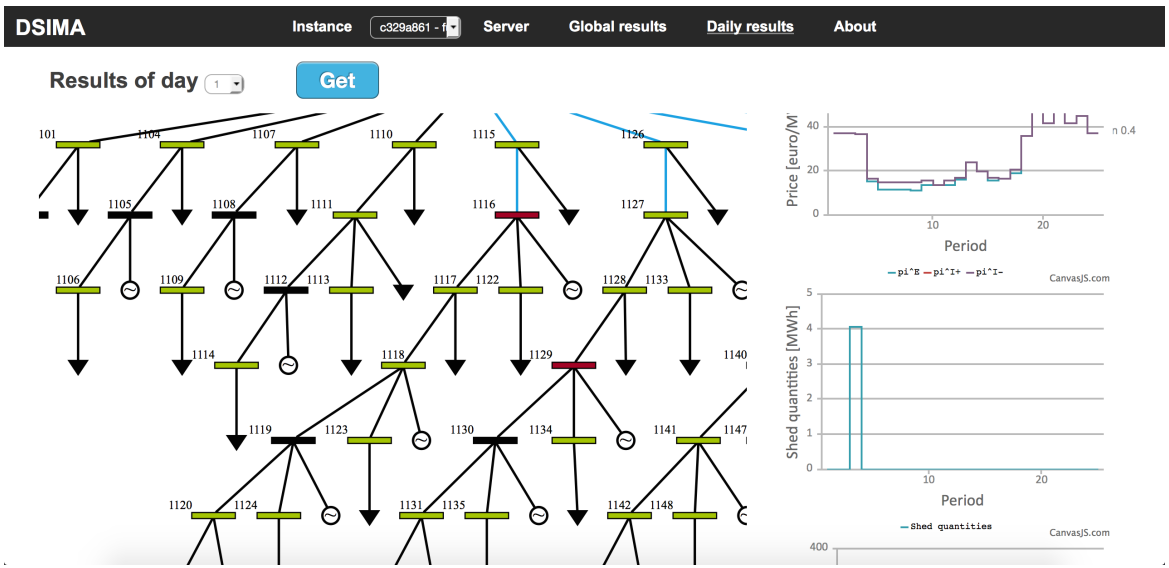


The TSO cannot ask anymore the storage unit to increase its production and the DSO prevents the congestion of line 3.

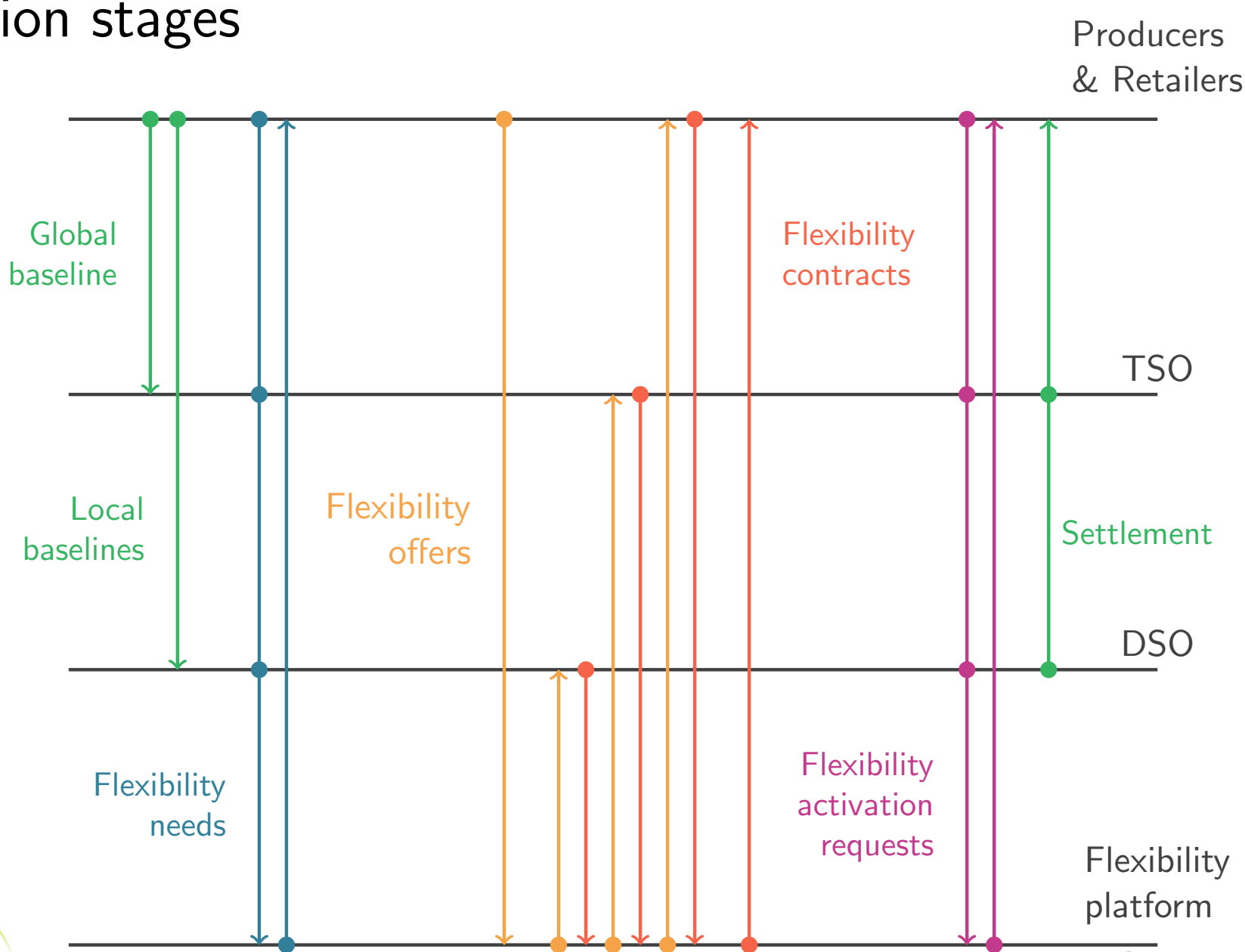
Outline

DSIMA: purpose & implementation

- To study short-term flexibility exchanges in an operational planning phase.
- The actors simulated are the DSO, the TSO, producers and retailers, and may fulfill more than one role.
- The testbed is available as an open source code at the address `http://www.montefiore.ulg.ac.be/~dsima/`.

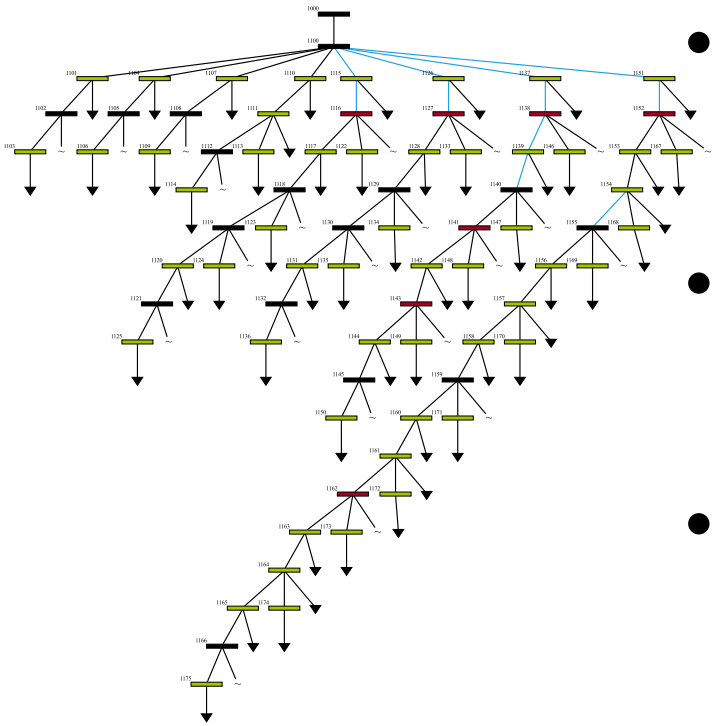


Decision stages



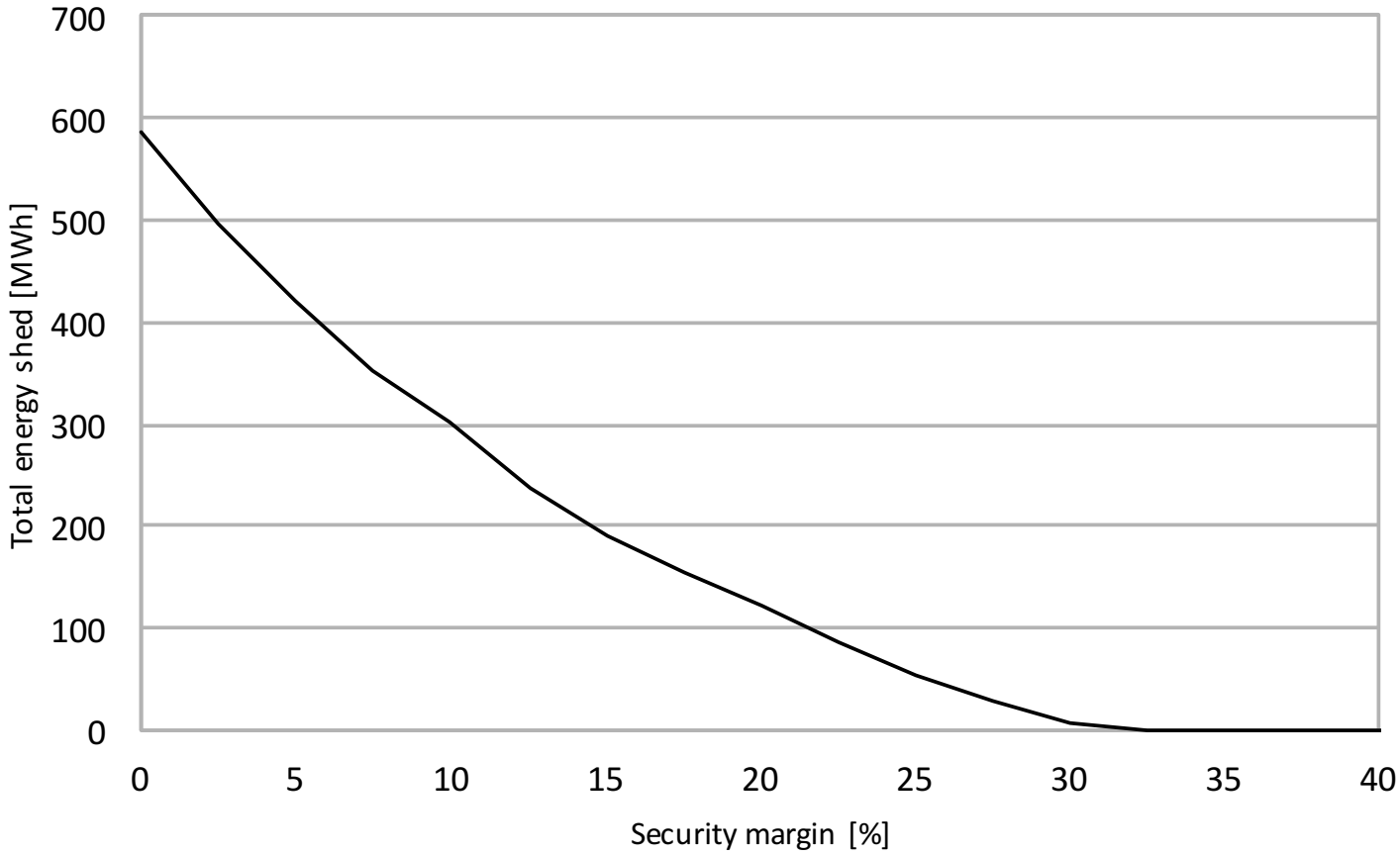
Outline

Case study



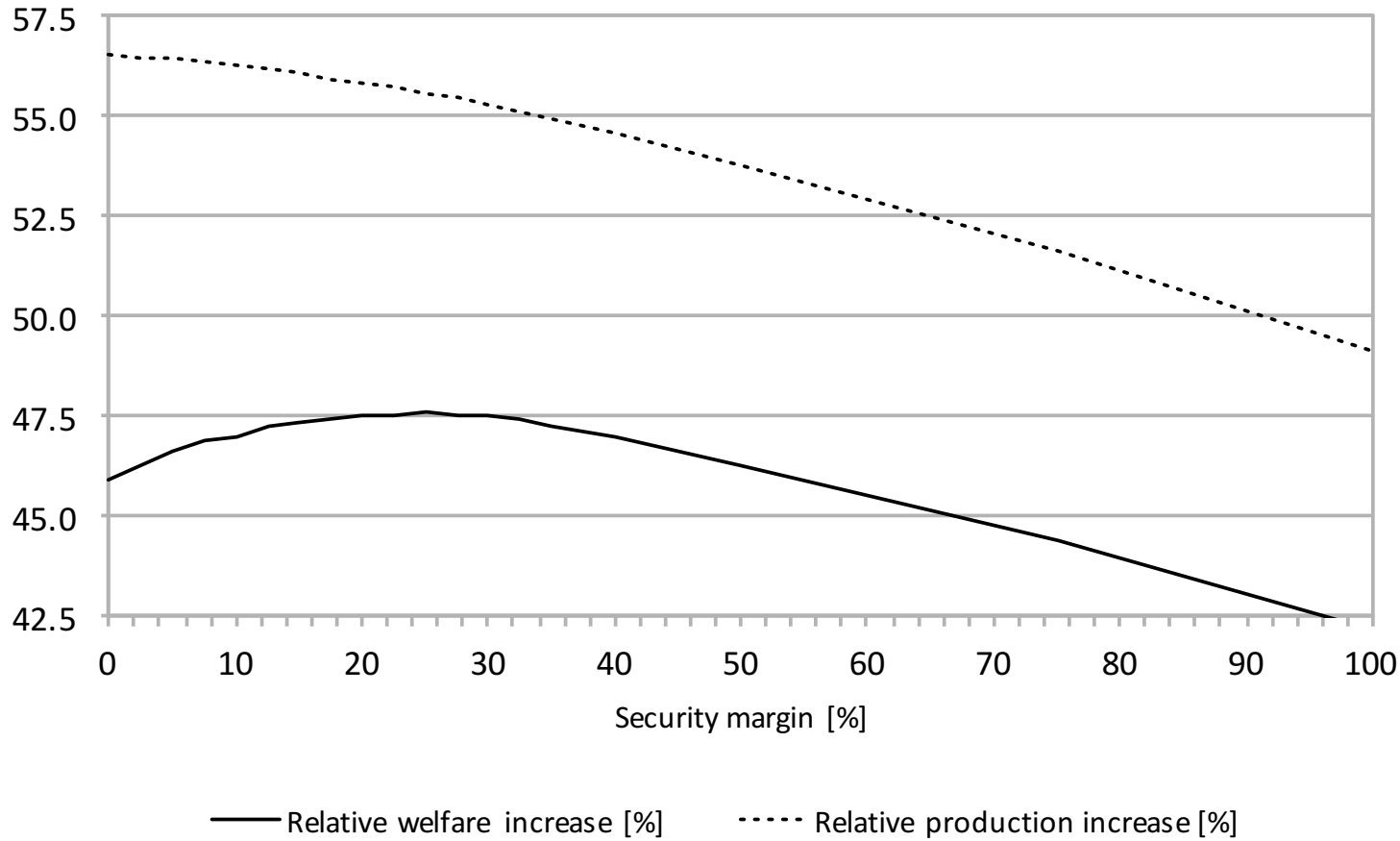
- Results are given for a 75 bus test system.
- Results show that the DSO should consider a security margin of at least 30% to avoid shedding issues.
- Welfare of the dynamic model is compared to a restrictive model where there is no flexible ranges and only safe access ranges.
- A practical choice for this application would be to consider security margins of 40%. Welfare would be increased with respect to the restricted model by 47% and the total production by 55%.

Evolution of the yearly shed production with the relative maximal deviation parameter considered by the DSO



Welfare and total production increase as a function of the relative maximal deviation parameter

with respect to a conservative interaction model.



Conclusion

Summary

- Study of flexibility services exchanges within a distribution system.
- Proposal of an interaction model with dynamic access bounds.
- These bounds are computed using baseline proposals.
- Compared to restrictive accesses, this model safely increases by 55% the distributed generation and the welfare by 42.5%.

Ongoing & future work

- Propose an interaction model solving the coordination problem DSO-TSO. ✓
- Refine the modeling level: AC power flow. ✓
- Study the entry or exit of new players or production units.
- Compare to network reinforcement decisions.

More information

Open-source testbed

`http://www.montefiore.ulg.ac.be/~dsima`

The Gredor project

`http://www.gredor.be`

Financed by the Public Service of Wallonia - Department of Energy and Sustainable Building for funding this research.

Appendix - Baseline proposal: motivation

A baseline proposal incentivize a grid user to produce in its dynamic range established on a definitive baseline.

Example: producer

Flexible range	**Baseline**	**Dynamic range**
$[5, 8]$MW	8MW	$[0, 6]$MW

Choices of the producer

1. Paying an imbalance of 2MW to the TSO.
2. Paying a penalty to the DSO for the 2MW of violation.
3. Selling a downward modulation of 1MW, produce 7MW and pay a 1MW penalty to the DSO.

Appendix - One day of a producer selling flexibility services

Assume a specific interaction model and one hour: 8 to 9am. A producer performs the following actions:

1. Send its baseline to the TSO at the high-voltage level.
   I will produce 15*MWh in distribution network* 42 *between 8 and 9am.*
2. Send its baseline to the DSO at the medium-voltage level.
   I will produce 5*MWh in bus* 20 *between 8 and 9am.*
3. Obtain flexibility needs of the flexibility services users.
   The DSO needs 3*MWh downward in bus* 20 *between 8 and 9am.*
4. Propose flexibility offers.
   I can curtail my production by 2*MWh in bus* 20 *between 8 and 9am.*
5. Receive activation requests for the contracted services.
   Curtail production by 1*MWh in bus* 20 *between 8 and 9am.*
6. Decide the final realizations.
   Produce 4*MWh or* 5*MWh in bus* 20 *between 8 and 9am.*